植物研究雑誌
J. Jpn. Bot.
70: 334–338 (1995)

Cytotaxonomical Studies of Siberian Sedoideae (Crassulaceae) I. Chromosomes of *Rhodiola* in the Altai Mountains

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(Received on June 29, 1995)

Chromosome number and karyomorphology of five species of *Rhodiola* were investigated in the Altai Mountains. The chromosome numbers were as follows: *Rhodiola algida*, 2n=14; *R. elongata*, 2n=24; *R. quadrifida*, 2n=20; *R.* aff. *quadrifida*, 2n=22; *R. rosea*, 2n=22. In the Altai Mountains the species seems to be diversified at diploid level with aneuploidy.

Siberia is one of the centres of the present diversification of Sedoideae (Crassulaceae), especially *Rhodiola, Hylotelephium* and *Aizopsis*. Cytological and cytotaxonomical studies of Siberian Sedoideae have been done to some limited number of the species. In this series of papers the authors will report the chromosome numbers of Sedoideae species and discuss them cytotaxonomical point of view.

The genus *Rhodiola*, consisting of about 50 species, is distributed in the Northern Hemisphere, highly concentrated in Himalaya and SW China (Yunnan and Sichuan) (Ohba 1981, 1982). Only seven species have been found in the Altai Mountains, but some of them might be expected to be the Himalayan element. If so, both Himalayan and Arctic elements may occur there sympatrically. Comparison between these two elements is much wanted in order to detect evolutionary pathway in *Rhodiola*.

Ohba and Wakabayashi have progressed cytotaxonomic studies of *Rhodiola*, though have not yet studied any Altai species. This paper aims to publish the chromosome number and karyotype of five species of *Rhodiola* collected from the Russian side of the Altai Mountains. Discussion about the cytological evolution and features of *Rhodiola* will be published in their forthcoming paper.

Materials and Methods

The materials were collected in 1992 from six localities in the Russian side of the Altai Mountains. The shoot apex used for cytological observations was fixed in the field. The pretreatment was made by 0.05% colchichine solution for about 4 h. at about 10°C. After pretreatment, the materials were fixed in Newcomer fluid. The maceration was carried out in 1% pectinase (EC 3.2.1.4; WAKO) for 40 min. at 37°C. The staining was carried out in 1% aceto-orcein for 4 h. at 20°C and then squashed. Voucher specimens are been deposited in TI.

Results

The chromosome numbers of the five Altai species

are given in Table 1 with their collection data. The metaphase chromosomes of each species are shown in Fig. 1. Brief descriptions of the cytological features of each species are as follows:

Rhodiola algida (Ledeb.) Fisch. et C.A. Mey.

2n=14 (Fig. 1c). This is the first record of chromosome number for the species. We observed materials from three localities, but no variation was found in chromosome number. The karyotype of this species is monomodal and symmetric, length of chromosomes is ranging from 1 to 2 μm.

Rhodiola elongata (Ledeb.) Fisch. et C.A. Mey.

2n=24 (Fig. 1e). This is the first record for the species. We observed chromosomes from four individuals in a single locality. The karyotype is monomodal and symmetric, the length of chromosomes ranges from 1 to 2 μm. In the locality we found the species grew together with *R. rosea* (2n=22), but there is no intermediate form between the two species.

Rhodiola quadrifida (Pall.) Fisch. et C.A. Mey.

Table 1. Chromosome numbers and voucher data of *Rhodiola* in the Altai Mountains

Taxon	Chromosome number (2n)	Number of examined	Voucher data: locality, specimen number, altitude in parenthesis
R. algida	14	2	Ukok, Tara valley, 9280446 (2590 m)
	14	1	Ukok, Tara valley, 9280447 (2490 m)
	14	1	Akturu river, 9280576 (2810 m)
	14	2	Multa lake, 9280610 (1840 m)
R. elongata	24	4	Ukok, Tara valley, 9280462 (2490 m)
R. quadrifida	20	1	Aktash, 920662 (?)
	20	4	Aktash, 920303 (2660 m)
	20	3	Sailgem river, 920670 (2670 m)
	20	5	Ukok, Tara valley, 920427 (2660 m)
	20	2	Ukok, Tara valley, 920428 (2690 m)
	20	2	Akturu river, 920575 (1580 m)
	20	2	Multa lake, 920663 (?)
R. aff, *quadrifida*	22	1	Ukok, Tara valley, 921212 (?)
R. rosea	22	1	Sailgem river, 920367 (2490 m)
	22	2	Kindikitiholi lake, 920392 (2650 m)
	22	2	Ukok, Tara valley, 920463 (2490 m)
	22	3	Akturu river, 920574 (1690 m)

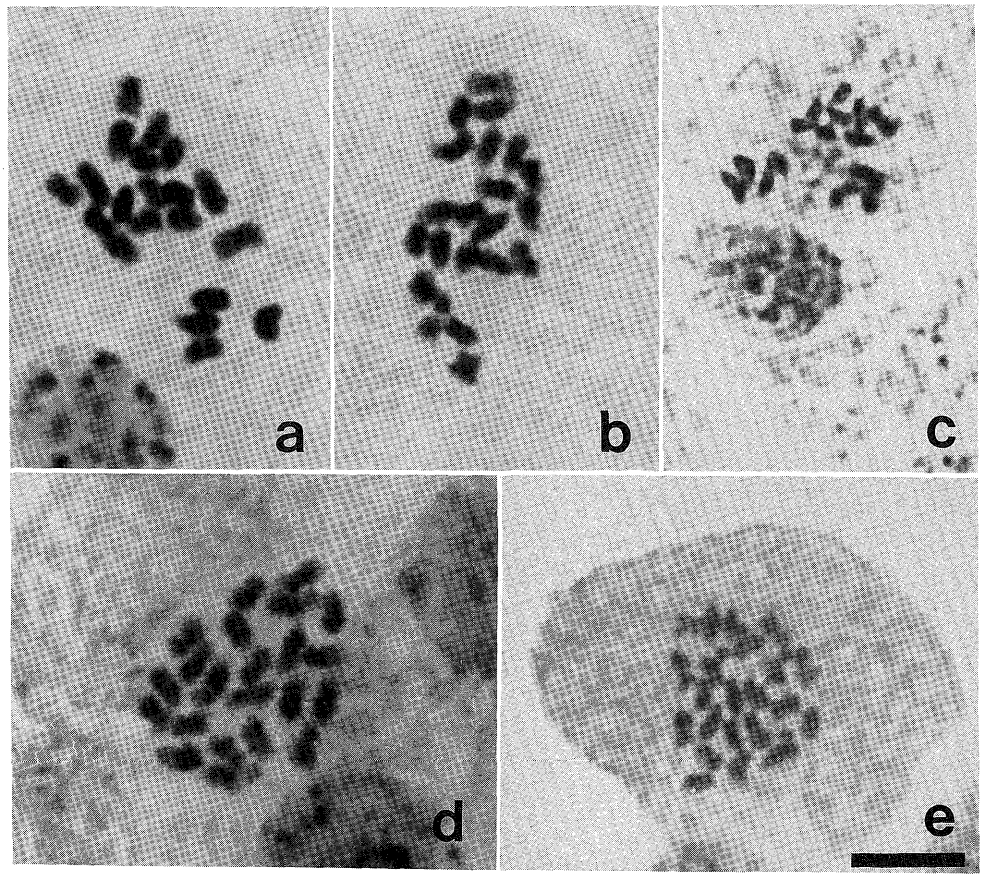

Fig. 1. Mitotic chromosomes of *Rhodiola* species. a: *R. quadrifida*, b: *R.* aff. *quadrifida*, c: *R. algida*, d: *R. rosea*, e: *R. elongata*. Bar indicates 10 μm.

2n=20 (Fig. 1b). We observed chromosomes from five localities, but there was no variation on chromosome number. The karyotype is monomodal and symmetric, and the length of chromosome ranging from 1 to 2 μm.

Rhodiola aff. *quadrifida* (Pall.) Fisch. et C.A. Mey.

This is similar to *Rhodiola quadrifida* (Pall.) Fisch. et C.A. Mey., but differs mainly by having lanceolate leaves with acute apex, 11.5 mm long and 3 mm wide. The chromosome number was counted as 2n=22 (Fig. 1b). We observed the chromosomes from a single individual. The karyotype is monomodal and symmetric, the length of chromosome ranging from 1 to 2 μm. It has a pair of small chromosomes with the complements of *R. quadrifida*.

Rhodiola rosea L.

2n=22 (Fig. 1d). We observed chromosomes in nine individuals from four localities. All have 2n=22 chromosomes. The karyotype is monomodal and symmetric, chromosome ranging from 1 to 2 μm in length. It has one pair of satellite chromosomes.

Discussion

Four different diploid numbers were found; i.e., 14, 20, 22 and 24 among the five species. It suggests that the basic chromosome numbers are x=7, 10, 11

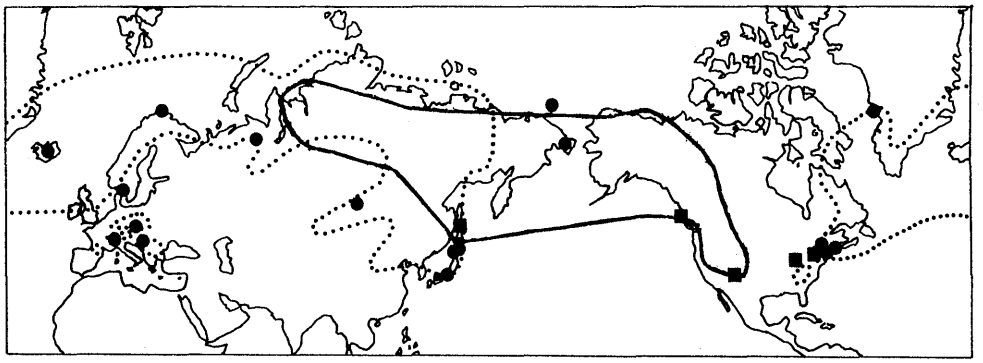

Fig. 2. The distribution ranges of *R. rosea* (dotted line) and *R. integrifolia* (solid line). Solid circles show the locality of the materials with 2n=22, and solid squares show those with 2n=36.

and 12. As Uhl (1961) pointed out the fact that many groups of Crassulaceae develop complicated polyploidy series. 't Hart (1978) presented a prominent example of serial polyploidy in the Acre and Rupestria groups in *Sedum*. Funamoto and Yuasa (1986) gave serial polyploidy in *Hylotelephium*. However, *Rhodiola* is thought to be diversified in diploid level.

The previous information of chromosome number in the genus has concentrated to *Rhodiola rosea*. However, the species delimitation was partially confused in some papers (Uhl 1952, Wien and Halleck 1962, Taylor and Mulligan 1968). Figure 2 shows the distribution ranges of *R. rosea* and *R. integrifolia* Rafin, and indicates the localities from which chromosome numbers were reported. The ranges overlaps in east Siberia. Chromosome number 2n=22 was found only in the range of *R. rosea*, while 2n=36 in that of *R. integrifolia*. Consequently, the materials with 2n=36 chromosomes might be *R. integrifolia*. *Rhodiola rosea* is distributed widely in Eurasian continent and East coast of North America. The chromosome number of *R. rosea* was reported from various areas covering the total range including Ural (Laverenko and Serditov 1987), Siberia (Zhukova 1962, 1982, Belaeva and Siplivinsky 1981), Chukotka peninsula (Zhukova 1980), Iceland (Löve and Löve 1956), Greenland (Engelskjöen and Schweizer 1970, Dalgaard 1989), Scandinavia peninsula (Engelskjöen and Knaben 1971), Slovenia (Susinik et al. 1972), Japan (Toyofuku 1935, Soeda 1944, Uhl and Moran 1972). This study can reveal the cytological identity of *Rhodiola rosea* in the Altai mountains.

Rhodiola elongata is often considered as conspecific with *R. rosea* (Ohba 1981). It is remarkable that *R. elongata* might be differentiated cytologically from *R. rosea*. The voucher specimens of *R. elongata* approach to the species of *R. macrocarpa* group such as *R. sherriffii* H. Ohba. It suggests that the plants so called *R. elongata* in the Altai is necessary to compare with the species of *R. macrocarpa* group.

We thank Professor I. M. Krasnoborov, Central Siberian Botanical Garden, Branch of Russian Academy of Science, for kindly help during the field expedition. This study was supported by Grants-in Aid (No. 04041087 to Wakabayashi in 1992, and No. 06041030 to Ohba in 1995) for Overseas Scientific Research from the Ministry of Education, Science and Culture, Japan.

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天野 誠，若林三千男，大場秀章：**シベリア産マンネングサ亜科の細胞分類学的研究 I. アルタイ山脈産イワベンケイ属の染色体数**

アルタイ山脈ロシア側で採集した5種のイワベンケイ属の染色体数と核型を調べた．判明した染色体数は，イワベンケイ 2n＝22，*Rhodiola algida* 2n＝14，*R. elongata* 2n＝24，*R. quadrifida* 2n＝20，*R. quadrifida* 近似種 2n＝22である．これらはいずれも基本数，7，10，11，12とする2倍体種と考えられた．